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*and Project Management*  
**Systems Engineering Development Opportunities  
within NASA's Academy of Program Project and  
Engineering Leadership**

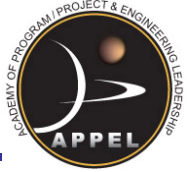
*Presentation to NASA Project Management  
Challenge 2007  
February 6-7, 2007*

***Tim Brady  
timothy.k.brady@nasa.gov***



## NASA's 21st Century Engineering Environment

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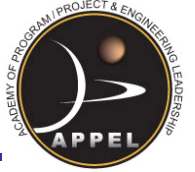


- Current and future programs have unprecedented levels of complexity
- Need for attention to Safety
- In-sourcing critical tasks
- Long development life cycle in the Vision for Space Exploration
- Changing stakeholders/expectations (Congress, public) over time
- Rapid innovation in technologies
- Large, Complex Organization
- Activities have high profile with the public



# Excellence in Systems Engineering

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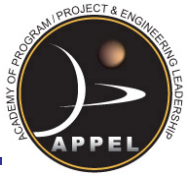


- For NASA to develop and sustain agency-wide excellence in Systems Engineering requires:
  - Curriculum to support individual development throughout a NASA career
  - Strong Foundations in fundamental concepts
  - Depth of understanding of NASA SE processes
  - Development opportunities to prepare Systems Engineers and Project Managers to lead complex technical projects



# Systems Engineering Competency Framework

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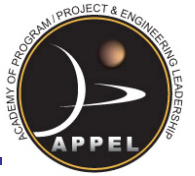


- Started in 2005 with NASA, DoD, industry, and academia to review systems engineering practices and establish NASA competency framework. Analysis inputs included:
  - NASA draft SE NPR
  - Center documents from MSFC, GSFC, JSC, KSC, ARC
  - NESC SE Proposed Competencies
  - DoD SE Guidebook
  - INCOSE SE Handbook
- Set of ten Systems Engineering competencies established
- Format of the final product consistent with the Project Management competencies
- Competency definitions were included in the process to update the APPEL curriculum



# Development of NASA SE Competencies

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- Five competency areas parallel Project Management competencies
  - NASA Internal and External Environments
  - Human capital Management
  - Security, Safety and Mission Assurance
  - Professional and Leadership Development
  - Knowledge Management
- Five competency areas distinguish Systems Engineering from Project Management
  - Concepts and Architecture
  - System Design
  - Production, Product Transition, Operations
  - Technical Management
  - Project Management and Control



# Systems Engineering Competencies

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## **1.0 Concepts and Architecture**

- 1.1 Mission Needs Statement
- 1.2 System Environments
- 1.3 Trade Studies
- 1.4 System Architecture

## **2.0 System Design**

- 2.1 Stakeholder Expectation Definition and Management
- 2.2 Technical Requirements Definition
- 2.3 Logical Decomposition
- 2.4 Design Solution Definition

## **3.0 Production, Product Transition, and Ops**

- 3.1 Product Implementation
- 3.2 Product Integration
- 3.3 Product Verification
- 3.4 Product Validation
- 3.5 Product Transition
- 3.6 Operations

## **4.0 Technical Management**

- 4.1 Technical Planning
- 4.2 Requirements Management
- 4.3 Interface Management
- 4.4 Technical Risk Management
- 4.5 Configuration Management
- 4.6 Technical Data Management
- 4.7 Technical Assessment
- 4.8 Technical Decision Analysis

## **5.0 Project Management and Control**

- 5.1 Acquisition Strategies and Procurement
- 5.2 Resource Management
- 5.3 Contract Management
- 5.4 Systems Engineering Management

## **6.0 NASA Internal and External Environments**

- 6.1 Agency Structure, Mission, and Internal Goals
- 6.2 NASA PM/SE Procedures and Guidelines
- 6.3 External Relationships

## **7.0 Human Capital Management**

- 7.1 Technical Staffing and Performance
- 7.2 Team Dynamics and Management

## **8.0 Security, Safety and Mission Assurance**

- 8.1 Security
- 8.2 Safety and Mission Assurance

## **9.0 Professional and Leadership Development**

- 9.1 Mentoring and Coaching
- 9.2 Communication
- 9.3 Leadership

## **10.0 Knowledge Management**

- 10.1 Knowledge Capture and Transfer



# Project Management Competencies

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## **Project Conceptualization**

- 1.1 Project Proposal
- 1.2 Requirement Development
- 1.3 Acquisition Management
- 1.4 Project Planning
- 1.5 Cost-estimating
- 1.6 Risk Management

## **Resource Management**

- 2.1 IT and MIS
- 2.2 Budget and Full Cost Management
- 2.3 Capital Management

## **Project Implementation**

- 3.1 Systems Engineering
- 3.2 Design and Development
- 3.3 Contract Management

## **Delivery, Operation, and Closeout**

- 4.1 Logistics Management
- 4.2 Stakeholder Management
- 4.3 Technology Transfer and Communication

## **Program Control and Evaluation**

- 5.1 Tracking/Trending of Project Performance
- 5.2 Project Control
- 5.3 Project Review and Evaluation

## **NASA Environment**

- 6.1 Agency Structure and Internal Goals
- 6.2 NASA PM Procedures and Guidelines
- 6.3 International Standards and Political Implications

## **Human Capital Management**

- 7.1 Position Management
- 7.2 Recruitment, Hiring and Retention
- 7.3 Team Dynamics and Management

## **Safety and Mission Assurance**

- 8.1 Environment and Ecology
- 8.2 Workplace Safety
- 8.3 Mission Assurance
- 8.4 Security

## **Professional and Leadership Development**

- 9.1 Mentoring and Coaching
- 9.2 Communication/Decision Making
- 9.3 Leadership
- 9.4 Ethics

## **Knowledge Management**

- 10.1 Knowledge Capture and Transfer
- 10.2 Knowledge Sharing



# Revised Structure of the APPEL Curriculum

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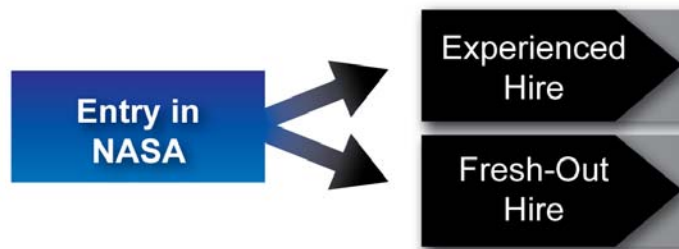
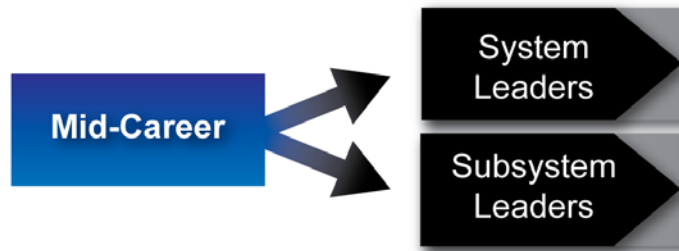
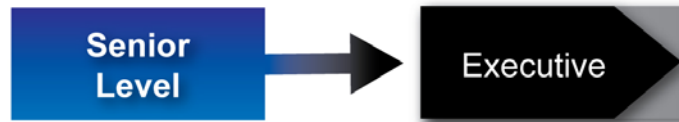
- APPEL course structure revised into two areas: Core Curriculum and In-Depth Courses
  - Core Curriculum:
    - ✓ Developed introductory course for new employees to understand NASA history, mission and organization as well as spaceflight technical fundamentals
    - ✓ Revised project management courses to integrate systems engineering.
    - ✓ Incorporated changes from governance model and project management/systems engineering NPRs.
  - In-Depth Courses
    - ✓ Updated to incorporate changes from governance model and project management/systems engineering NPRs.
    - ✓ In-Depth Systems Engineering Courses reviewed for content covering the Systems Engineering competencies.



# APPEL Core Curriculum



## Target Audience



## New/Updated Content

### APPEL Executive Program

- New Program
- 20 high-potential leaders selected by Center or Agency leaders
- Executive issues and executive-level decision-making

### Advanced Project Mgmt and Systems Eng

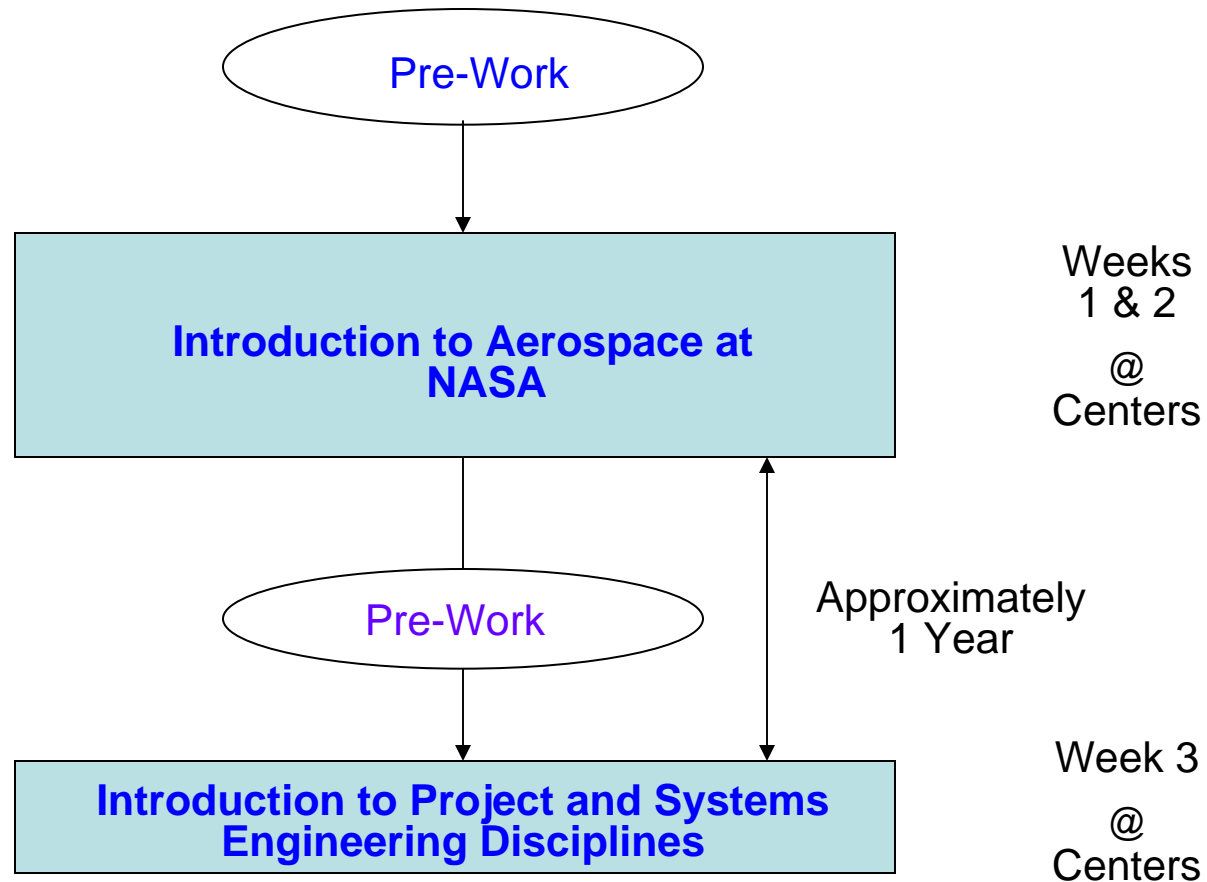
- Inclusion of systems engineering content
- Use of case studies to develop systems thinking and address complex projects/systems issues

### Project Mgmt and Systems Eng

- Inclusion of systems engineering content
- Applying PM/SE processes/ practices over project life cycle
- Concepts, tools and techniques to plan, organize and lead complex projects

### Foundations of Aerospace at NASA

- Governance model
- HQ, Center roles and responsibilities
- NASA mission, vision, history
- Awareness of directives, policies and procedures
- Essentials of project management and systems engineering
- Intro to discipline engineering essential to NASA's mission
- NASA leaders address participants





# Foundations Curriculum

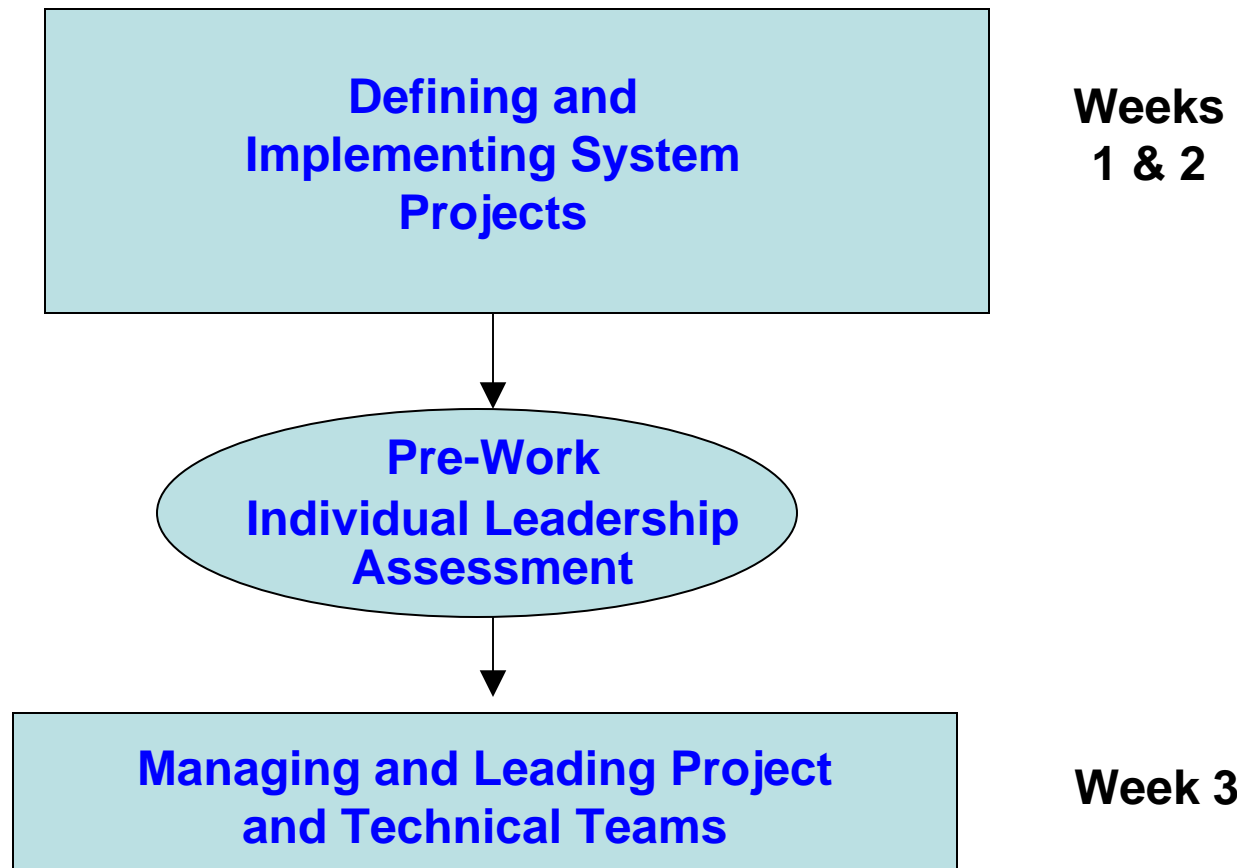
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- Audience
  - New Hires in their first year of employment at NASA
  - For initial offerings audience will also include those who have come into NASA in last 5 years
- Core Design Approach
  - Two-week Part A
    - ✓ Describe the NASA vision, mission, governance model and history
    - ✓ Describe the “big picture” of NASA, the agency, and how the infrastructure works
    - ✓ Explain the concept of systems thinking and associated trades.
    - ✓ Language and overview of concepts of aeronautics and astronautics
    - ✓ Introduction to concept of systems integration and systems thinking
    - ✓ Demonstrate skills necessary for effective communication and teamwork
  - One-Week Part B
    - ✓ Describe project management methodologies and systems engineering processes
- Schedule:
  - Part A: 3/26-4/6 (JSC), 4/23-5/4 (MSFC); GRC, ARC, LaRC later in FY
  - Part B: 4/23-27 (JSC), 5/21-25 (KSC), 7/9-13 (GSFC), 8/27-31ARC



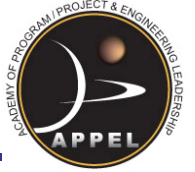
# Project Management and Systems Engineering Curriculum -- Structure





# Project Management and Systems Engineering Curriculum

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- Audience
  - Personnel in first year of, or just prior to, entry into a project, systems engineering, or supervisory position
- Objective
  - Enhance proficiency in applying Project Leadership and Systems Engineering discipline processes/ practices over project life cycle
- Core Design Guidelines
  - Two-week Part A focuses on Project Leadership and Systems Engineering knowledge/skill requirements, and one-week Part B focuses on team leadership
  - Describes project life cycle (NPR 7120.5D) and systems engineering processes (NPR 7123.1A)
  - Major subject areas include:
    - ✓ Requirements definition
    - ✓ System definition, realization and evaluation
    - ✓ Operations
    - ✓ Risk management
    - ✓ Acquisition and contract management
    - ✓ Project performance and earned value management
    - ✓ Leading Project and technical teams
- Schedule
  - Part A – starting 4/30 (GRC), 6/4(MSFC) (LaRC)
  - Part B – starting 3/26, 4/30, 9/10 (Wallops)



# Advanced Project Management and Systems Engineering Curriculum

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- Audience
  - Personnel prior to or in the first year of entry into senior Project Leadership or Lead Systems Engineering position
- Goal
  - Enhance proficiency in integration of Project Management and Systems Engineering knowledge/skills to manage/lead a significant project activity
- Core Design Guidelines
  - One-week course
    - ✓ Three days - Concepts, tools and techniques to plan, organize and lead complex projects
    - ✓ Two days - utilizes case studies to apply management techniques; Examples of planned cases: Gravity Probe B, STS-115 Hurricane Decision, Robotic vs Human repair of HST, Viking GCMS
- Schedule – Starting 3/26 (Wallops) 5/7 (GRC), 9/10 (Wallops)



# Advanced Project Management & Systems Engineering Curriculum – Course Content

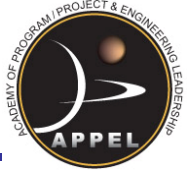


Monday	Tuesday	Wednesday	Thursday	Friday
Leading Complex Projects			Case Studies	
<ul style="list-style-type: none"> <li>• Understanding Complexity in Projects</li> <li>• Complex Project Model and Processes</li> <li>• Determining Project Complexity</li> <li>• Communicating Project Complexity</li> <li>• Designing for Complexity</li> <li>• Governing Project Complexity</li> </ul>			<ul style="list-style-type: none"> <li>• 6 case studies from:               <ul style="list-style-type: none"> <li>• NASA and other</li> <li>• Large and small projects</li> <li>• Robotic and human flight projects</li> </ul> </li> <li>• Cases encompassing significant successes and failures</li> </ul>	



# APPEL Executive Program

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- Audience
  - Twenty invited participants
  - Five senior Project & Engineering Leaders
  - Fifteen high potential future Project and Engineering Leaders selected by AA's, Center Directors or NASA Chief Engineer
- Core Curriculum Goal
  - Will use the case study method on four current challenges within the agency that required Executive Decision making.
  - Participants will understand the constraints and discuss the process utilized in reaching a decision
- Schedule - TBD

# APPEL In-Depth Courses – February 2007

## Project Management

Acquisitions &  
Contracting Workshop  
 Integrating Cost &  
Schedule  
 International Project  
Management  
 NASA's Budgeting  
Process  
 Performance-Based  
Statement of Work  
 Project Management  
Leadership Lab  
 Project Planning  
Analysis & Control  
 Scheduling & Cost  
Control  
 Leading Complex  
Projects  
 Earned Value (In  
Development)  
 Advanced Earned Value  
(In Development)

## Project Management & Systems Engineering

Lifecycle, Processes, &  
Systems Engineering  
 Project Review Processes  
& Strategies  
 Requirements Dev &  
Management  
 Foundations of Risk  
Management  
 Continuous Risk  
Management

## Communications & Leadership

Comm Technical Issues  
 Negotiations  
 Team Leadership  
 Team Membership  
 Tech Writing for Engineers

## Systems Engineering

Concept Exploration  
& System  
Architecting  
 Decision Analysis  
 Developing &  
Implementing a  
Systems  
Engineering  
Management Plan  
 Space Systems V&V  
 Transition, Product  
Delivery, & Mission  
Operations  
 Cal Tech Cert Prog  
(Pilot)

## Other

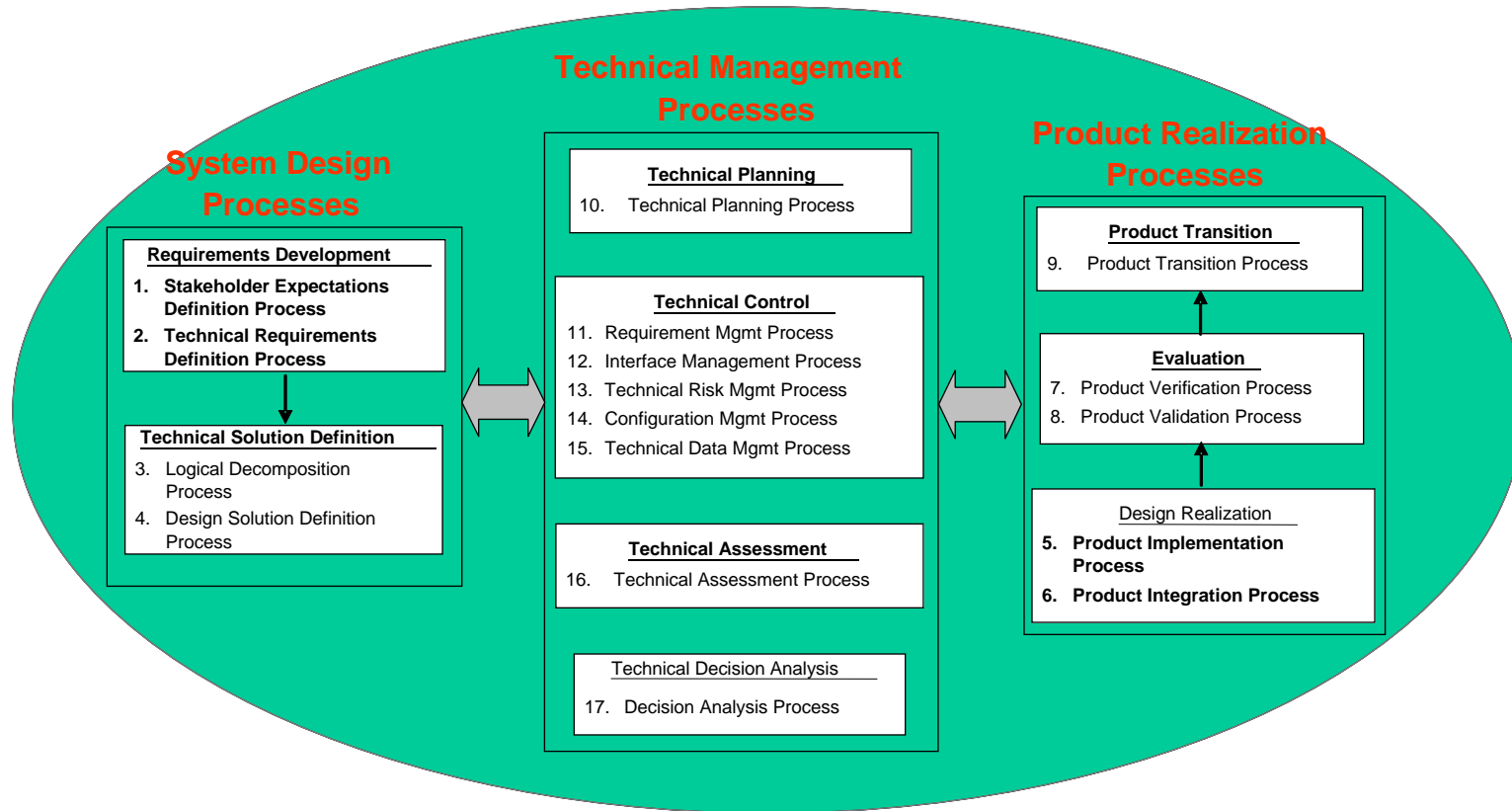
Innovative Design  
for Eng Apps  
 Seven Axioms of  
Good Eng –Learning  
from Failure

## NASA

Introduction to  
Aeronautics  
 Introduction to  
Aerospace  
 Mars Mission System  
Design  
 Science Mission  
Systems Design &  
Operations  
 Science Mission  
Systems Design &  
Operations Lab  
 Space Launch &  
Transportation  
Systems



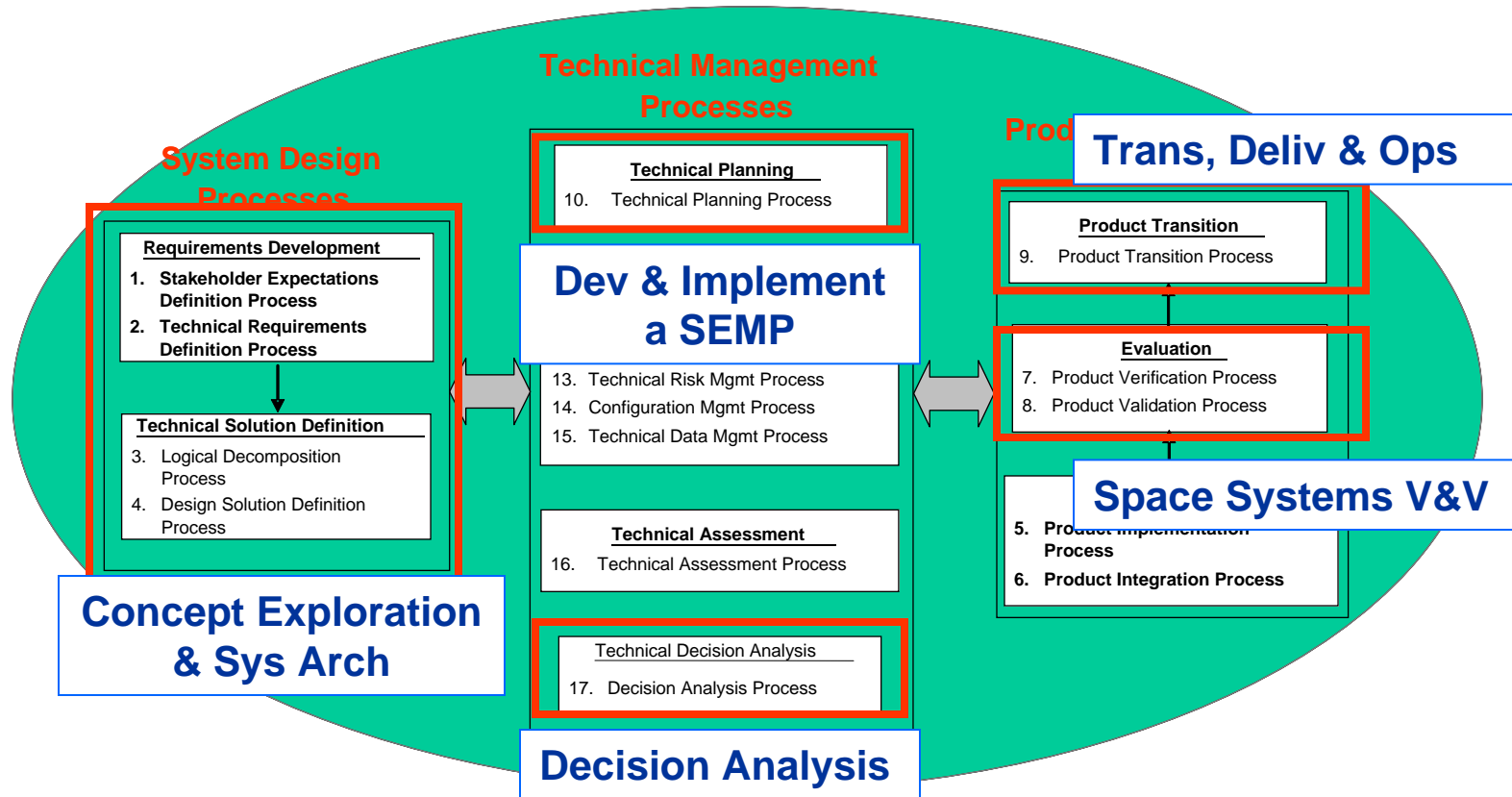
# APPEL Systems Engineering Curriculum Architecture



- APPEL SE Curriculum must cover the breadth of the SE Processes outlined in NPR 7123.1
- SE Curriculum must also deliver sufficient depth of knowledge for Project Managers, Systems Engineers, Project team members and Systems Engineering discipline experts



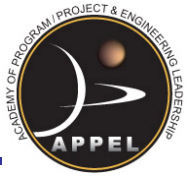
# APPEL Systems Engineering Curriculum Mapping to NPR 7123





## Comments on In-Depth Courses

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- In-depth offerings are designed to augment skills provided in the core curriculum.
- All previously offered APPEL in-depth offerings are available.
  - Previous numerical course identifiers have been eliminated in favor of simplified acronyms.
- Pay attention to the notes in the course catalogue



# Individual Opportunities

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- Set up Individual Development Plan (IDP) with supervisor or mentor
- For scheduled courses, register in SATERN
  - Register early; electronic registration closes out generally 7 weeks before the class
  - The learning plan feature can be used by you or your supervisor to identify desired training without registering



# SATERN Learning Plan



Welcome TIMOTHY BRADY | [Home](#) | [Search Catalog](#) | [Go](#) | [? Help](#) | [Logout](#)

[Personal](#) | [Learning](#) | [Catalog](#) | [Reports](#)

- **Learning Plan** • [Learning Calendar](#) • [Current Registrations](#) • [Curriculum Status](#) • [Learning History](#) • [Record Learning](#) • [External Training Requests](#)

## Learning Plan

This page displays the complete list of the items specifically assigned to you based on your learning needs. The list includes items that you are required to complete on a recurring basis as well.

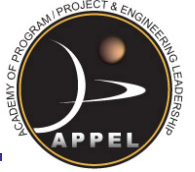
[\[Expand All\]](#) [\[Collapse All\]](#)

Learning Plan					
		Items: <span>All</span>		Required: <span>All</span>	
Title	Type	Required By	Status	Action	Remove
▶ APPEL-1CC-FOUNDATION OF AEROSPACE AT NASA PART A	👤		Must be registered	<a href="#">Register</a>	<a href="#">✕</a>
▶ APPEL-CONCEPT EXPLORATION AND SYSTEM ARCHITECTING	👤		Must be registered	<a href="#">Register</a>	<a href="#">✕</a>
▶ APPEL-CONCEPT EXPLORATION SYSTEM ENGINEERING FUNDAMENTALS	👤		Must be registered	<a href="#">Request Schedule</a>	
▶ APPEL-DEVELOPING AND IMPLEMENTING A SYSTEMS ENGINEERING MANAGEMENT PLAN	👤		Must be registered	<a href="#">Register</a>	<a href="#">✕</a>
▶ APPEL-LIFECYCLE, PROCESSES, AND SYSTEM ENGINEERING	👤		Must be registered	<a href="#">Register</a>	<a href="#">✕</a>
▶ APPEL-SEVEN AXIOMS OF GOOD ENGINEERING	👤		Must be registered	<a href="#">Register</a>	<a href="#">✕</a>



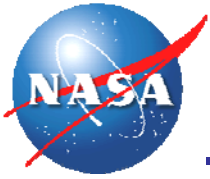
# Individual Opportunities

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- Set up Individual Development Plan (IDP) with supervisor or mentor
- For scheduled courses, register in SATERN
  - Register early; electronic registration closes out generally 7 weeks before the class
  - The learning plan feature can be used by you or your supervisor to identify desired training without registering
- For desired courses not on the APPEL schedule or not at your center, Communicate course requests to local training coordinator
  - High demands can be re-evaluated for APPEL delivery in FY07
  - Centers can procure courses
  - Long-term course demands can be used to prioritize APPEL and center offerings in next FY
- Individual and team assessment resources are available through APPEL
- Explore other resources available through your center
  - Formal center SE or PM development programs
  - Systems Engineering programs through local universities or distance learning

For revised charts email: [timothy.k.brady@nasa.gov](mailto:timothy.k.brady@nasa.gov)



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## Backup



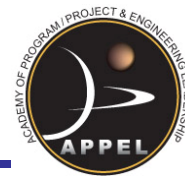
# Near-Term Core and In-Depth APPEL Schedule



	Location	Dates	Notes
February APPEL Courses			
Space System Verification and Validation	GRC	Feb 13-15	
Concept Exploration and System Architecting	JSC	Feb 26-Mar 2	SATERN Regist Closes Feb 7
March APPEL Courses			
Developing and Implementing a Systems Engineering Management Plan	JSC	Mar 6-8	
Project Planning Analysis and Control	MSFC	Mar 12-16	
Seven Axioms of Good Engineering	JSC	Mar 19-21	
Decision Analysis	GRC	Mar 20-21	
Project Management & Systems Engineering-Part B	WFF	Mar 26-30	
Advanced Project Management & Systems Engineering	WFF	Mar 26-30	
Foundations of Aerospace at NASA-Part A	JSC	Mar 26-Apr 6	
April APPEL Classes			
Lifecycle, Processes and Systems Engineering	JSC	Apr 3-5	
Requirements Development and Management	JSC	April 10-12	
Masters Forum 14	TBD	April 10-12	
Space System Verification and Validation	JSC	Apr 16-18	
Foundations of Aerospace at NASA-Part B	JSC	Apr 23-27	
Requirements Development and Management	GRC	Apr 24-26	
Foundations of Aerospace at NASA-Part A	MSFC	Apr 23-May 4	
Project Management & Systems Engineering-Part B	WFF	Apr 30-May 4	



# Foundations Curriculum -- Introduction to Aerospace at NASA Course Content



## Week 1

Monday	Tuesday	Wednesday	Thursday	Friday
<b>NASA</b>	<b>Communications</b>		<b>Working in Teams</b>	
<ul style="list-style-type: none"> <li>• Course Introduction</li> <li>• Welcome Address</li> <li>• NASA History</li> <li>• NASA's Present Mission - the Strategic Plan</li> <li>• Shuttle FRR Case Review</li> <li>• Technical Excellence &amp; PMDP</li> </ul>	Case Study in Communications Communications Course <ul style="list-style-type: none"> <li>• Clear direct wording</li> <li>• Format devices</li> <li>• Technical writing process</li> <li>• Audience analysis</li> <li>• Offering a Dissent</li> <li>• Organizing technical documents</li> <li>• Illustrations</li> <li>• Electronic Presentations</li> <li>• Editing and proofreading</li> </ul>		Team Membership <ul style="list-style-type: none"> <li>• Staffing project teams at NASA</li> <li>• Characteristics of effective team members and superior teams</li> <li>• Importance of teamwork</li> <li>• Group dynamics, problem solving, brainstorming</li> <li>• Conflict resolution</li> <li>• How to be effective in a team environment</li> </ul>	



# Foundations Curriculum -- Introduction to Aerospace at NASA Course Content



## Week 2

Monday	Tuesday	Wednesday	Thursday	Friday
NASA	Introduction to Aeronautics and Astronautics			
<ul style="list-style-type: none"><li>• TRL's</li><li>• Explorations Systems Mission &amp; Constellation</li><li>• Working with Foreign Governments</li><li>• Working with Other Agencies</li><li>• Working the Hill</li><li>• The budget process and working with Contractors</li></ul>	<b>Basic Aeronautics</b> <ul style="list-style-type: none"><li>• Vocabulary</li><li>• Aerodynamics</li><li>• Engines</li><li>• Structures</li><li>• Control</li><li>• Design considerations and trades</li></ul>	<b>Understanding Space</b> <ul style="list-style-type: none"><li>• Celestial mechanics</li><li>• Space environment</li><li>• Space Payloads - sensors</li><li>• Spacecraft subsystems</li><li>• Launch vehicle &amp; launch system</li><li>• Mission operations</li><li>• Design considerations</li><li>• Interdependence of all systems</li></ul>		



# Foundations Curriculum - Introduction to Project Management and Systems Engineering



## Week 3

Monday	Tuesday	Wednesday	Thursday	Friday
Class Introduction Course Introduction Presentations PM/SE Policy & Requirements Life Cycle Technical Reviews Requirements Development and Management	Presentations System development Planning and WBS Scheduling SE Engine Resource Development	Presentations Risk Management Project Documentation SEMP/PP/Etc.  Acquisition	Presentations Configuration Management  Project Control Completion of Contract and Closeout Preparing for Operations Example Projects Summary	
Fireside Chat	Open	Open	Graduation	



# Project Management & Systems Engineering

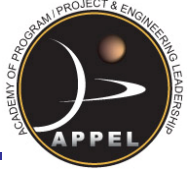


## Week 1 - System Definition and Development

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
<b>PM &amp; SE Overview</b> <ul style="list-style-type: none"> <li>• Governing Documents</li> <li>• Life Cycle</li> <li>• Processes Overview</li> <li>• Accountability, Roles and Responsibilities</li> <li>• Agency Requirements</li> </ul>	<b>Requirements Definition</b> <ul style="list-style-type: none"> <li>• Stakeholder Requirements</li> <li>• Technical Requirements</li> <li>• Logical Decomposition</li> <li>• Physical Solution</li> </ul>		<b>Acquisition</b> <ul style="list-style-type: none"> <li>• Planning &amp; Strategy</li> <li>• Requirements and SOW</li> <li>• Solicitation &amp; Evaluation</li> <li>• Contract Types</li> <li>• Negotiation</li> <li>• Surveillance</li> </ul>	<b>System Definition, Realization, &amp; Evaluation</b> <ul style="list-style-type: none"> <li>• System Implementation</li> <li>• System Integration</li> <li>• Space System V &amp; V</li> <li>• S/W V &amp; V</li> <li>• Pre-launch and Early Operations V &amp; V</li> <li>• Decision Analysis</li> </ul>	



# Project Management & Systems Engineering



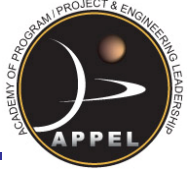
Week 1 -  
Contd.

Week 2 - Project Definition and Control

Day 7	Day 8	Day 9	Day 10	Day 11
Operations	Planning Scheduling & Costing		Risk Management	Control
<ul style="list-style-type: none"> <li>• Function</li> <li>• Concept Development</li> <li>• Communications Architecture</li> </ul>	<ul style="list-style-type: none"> <li>• WBS Development</li> <li>• Scheduling</li> <li>• Resources Development</li> </ul>		<ul style="list-style-type: none"> <li>• Principles</li> <li>• Identification</li> <li>• Analysis</li> <li>• Planning</li> <li>• Tracking &amp; Control</li> <li>• Communications &amp; Documentation</li> </ul>	<ul style="list-style-type: none"> <li>• EVM</li> <li>• Project Reviews &amp; Assessments</li> <li>• Independent Assessments</li> </ul>



# Project Management & Systems Engineering



## Week 3 - Managing and Leading Project and Technical Teams

Day 1	Day 2	Day 3	Day 4	Day 5
Human Capital Management	Individual Leadership	Team Leadership		
<ul style="list-style-type: none"><li>• Position Management</li><li>• Recruitment Hiring and Retention</li></ul>	<ul style="list-style-type: none"><li>• Organization of leadership</li><li>• Individual leadership assessment results</li><li>• Leadership effectiveness</li></ul>	<ul style="list-style-type: none"><li>• Team development</li><li>• Getting buy-in</li><li>• Understanding motivational needs</li><li>• Learning synergy</li></ul>		



# Advanced Project Management & Systems Engineering Curriculum – Course Content



Monday	Tuesday	Wednesday	Thursday	Friday
Leading Complex Projects			Case Studies	
<ul style="list-style-type: none"> <li>• Understanding Complexity in Projects</li> <li>• Complex Project Model and Processes</li> <li>• Determining Project Complexity</li> <li>• Communicating Project Complexity</li> <li>• Designing for Complexity</li> <li>• Governing Project Complexity</li> </ul>			<ul style="list-style-type: none"> <li>• 6 case studies from:               <ul style="list-style-type: none"> <li>• NASA and other</li> <li>• Large and small projects</li> <li>• Robotic and human flight projects</li> </ul> </li> <li>• Cases encompassing significant successes and failures</li> </ul>	